Lizard NDE Ltd

Field Gradient Imaging- Alternating Current Field Measurement - Electromagnetic Array - Classic Eddy Current

Non-Destructive Testing Systems For Asset Integrity Management

Basepoint, Havant, Hampshire, UK, PO9 1HS Tel: +44 (0) 2392 449656 Email: info@lizard.co.uk

ADVANCED NON-DESTRUCTIVE TESTING SOLUTIONS

An Introduction to the Lizard NDE Technology

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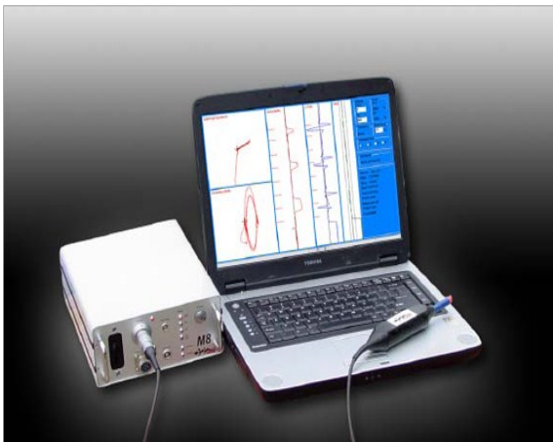
An Overview of the Lizard NDE Technology



Lizard M8 inspection system

LIZARD NDE LTD is a UK solutions based company and the manufacturers and inventors of cutting edge Non Destructive Testing technologies with a pedigree tracing back over 30 years. Lizard® technology has been used by blue chip clients in nuclear, aerospace, rail, petrochemical, offshore, pharmaceutical, civil engineering and gas and water utilities. The Lizard® technology product range is based upon advanced electromagnetic interrogation methods for highly accurate and repeatable inspection for the integrity assessment of both ferrous and non-ferrous material. Lizard® are experts at providing turn key solutions to problematic inspections requiring new NDT technology, procedures and know how as to the client requirements. Each of our products that we offer are the result of a client consultancy undertaking and the first inspection campaigns utilising the solution.

The technology is a direct replacement for many NDE procedures being capable of sizing true crack information, depth, length and location with no requirement for cleaning or coating removal.

Most other inspection procedures require the removal of paint or other coatings from the structure to be inspected prior to the actual inspection campaign. It is widely known that the removal of such protective coatings can, in itself, be the cause of damage to the structure whilst the re-instatement of these on site can be very difficult and costly to perform. Since the Lizard® technology is non-contacting it can 'see through' and measure the thickness of such coatings and does not require these to be removed enabling an extremely quick turnaround of inspection projects.

All scan data is captured digitally such that the inspection data can be recorded for audit purposes and any defects analysed either in real time or historically. This allows users to identify defects and better plan maintenance of a structure by recording the position, size and severity of a defect and re-inspect at intervals as appropriate to monitor growth. It is through this technique that for the first time owners of assets can have access to the full information required for planned maintenance of a structure to extend asset life.

The latest evolution of the Lizard® technology is the novel Versatile Array configuration that permits the inspection of welds in the nuclear industry of mixed metal composition and metal cladding in a single pass. The technology can be used not only for quality control and confirmation of integrity of new structures but also for the measurement of material changes associated with fatigue and wear as well as correlating near wall and far wall corrosion and defects.

In its' latest form, the Lizard® Versatile Array technology can also uniquely be configured to measure induced strain within structures, again the technology is non-contacting and can be deployed with no removal of coatings. In terms of strain measurement, the only technique currently available to industry is to glue conventional strain gauges to fixed points along the structure and then return to record measurements.

The Lizard® technology has been successfully coupled with other NDT technologies such as phased array ultrasonics and robotic deployment where the inspection program and task requires this capability.

The Lizard M8 in use performing an inspection through a protective coating

The Lizard® technology has been the proud recipients of prestige awards such as:-

- **The 'Sir Robert Horton Award for the Most Significant Contribution to Safety' for the Rail Industry**
- **UK Department of Trade and Industry 'SMART' Award**
- **Railway Forum Engineering Excellence Award**

Advantages of the Lizard® Technology

- **Ability to locate and size the length and depths of defect and measure strain, giving complete management information to assess the structural life and management interval needed for the structure**
- **No requirement to clean, remove paint, remove sprayed metal or galvanising to conduct the inspection therefore no additional damage to the structure and far less downtime for the asset inspected**
- **No requirement to re-instate protective coatings due to the non-contacting method used**
- **No couplant required or coating removal/re-instatement therefore environmentally friendly and biologically non-invasive**
- **Fully auditable. Each scan consists of a digital file containing scan data and text entries for archive purposes**
- **The ability to monitor growth of defects and therefore extending asset life**
- **Operator friendly with multiple analysis modes on a single display in real-time for easier defect detection and sizing covering multiple forms of electromagnetic inspection methods in a single pass. This ensures that all current or historic electromagnetic inspection regimes are supported (EN1711, EN473 and ASTM E2261-07) together with advanced modes available from Lizard®**
- **Additional probe port and support in software to enable the use of third party Classic Eddy Current style probes and we believe that the Lizard® is the only system fully compliant with ASTM E2261-07 in a stand-alone unit**
- **Profiled, multi sensor probes to enable rapid, single pass scanning of various weld geometries, covering weld toe, heat affected zone and weld cap**
- **Custom probe profiles can be constructed upon request to meet the client requirements**
- **Topside or subsea variants available to suit the application (23 bar water depth as standard)**
- **The ability to deploy remotely using rope access and robotic scanning technology**
- **The process and technology is constantly evolving to solve client integrity assessment tasks with the latest embodiments of joint techniques such as Lizard® FGI coupled with ultrasonic phased array technology**

Summary Defects	MPI	UT	LIZARD
Surface breaking defects	Yes	No	Yes
Suitable for coated surfaces	No	No	Yes
Surface cleaning not required	No	No	Yes
Crack length and depth indication	No	No	Yes
Auditable inspection records	No	Yes	Yes
Auditable data acquisition	No	No	Yes
Integrated quality assurance	No	No	Yes
Not limited by surface geometry	Yes	No	Yes
Ideal for automated inspections	No	Yes	Yes

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Standard Inspection using the Lizard® M8 and LP600 Lizard Probe

Out of a collaboration program with most of the oil majors and the Atomic Energy Authority Lizard® Electromagnetic Array Systems were originally developed as a response in the early 1990's against the requirement to inspect the subsea integrity of aging offshore oil platforms in the North Sea and to estimate and plan asset life. The target being to have a diver under air or saturation diving conditions inspect all platform welds below water for defects greater than 20mm long by 2mm deep without the requirement for cleaning and /or coating removal.

During trials Lizard® technology comprising EMA and AC Field Measurement completely outperformed existing practices and dismissed the continued use of conventional procedures such as Magnetic Particle inspection. Shell, Elf, BP and Norske Hydro specified the Lizard® technologies and procedures frontline which enabled remedial grinding out of sub-critical defects, platform life extension and extending out guidelines for platform life inspection. Following the success of below water applications the Lizard® technology use was extended front line to include above water applications on the basis of a better quality of inspection and no coating removal requirement.

Lizard®FGI Pedestrian Unit for the Inspection of Rail

Following further development works the Lizard® technology was further refined with the invention of the Lizard® Field Gradient Imaging (FGI) technology. Using this unique technology the Lizard® was adopted by the UK rail network for the detection of rolling contact fatigue on plain rail and points and crossings in addition to applications for railway freight and passenger vehicles with Alstom Transport. Following a major review linked with a derailment of a passenger train and loss of life the technology was chosen to free up the rail network from consequent speed restrictions imposed by HMRI (Her Majesty's Railway Inspectorate).

Field Gradient enhanced the Lizard® system capability for defect length and depth measurement and providing in one system under software control the additional electromagnetic modes of FGI, EMA, AC Field Measurement and existing classic eddy current. This development of the Lizard® M8 NDE System was inspired by the certifying authority DNV and provided that the general procedures for inspection were approved by DNV and others for class 1A1 structures and adopted by major offshore contractors. General procedures, formal training course curriculum and approval by societies such as ASTM were put in place with the Lizard® M8 being the focus.

Subsequent development inspection contracts during the late 2000's led to the development of the Versatile Array Technology and its adoption into the Nuclear power industry for the ability to provide inspection capability with metal cladding and mixed metal welding. In addition the technology was identified by UK Naval architects and asset life support for deployment on life extension of two significant front-line Royal Navy Ships, where the technology enabled one ship to remain in service for an additional five years.

Nuclear PWR application and CAD presentation of robotically deployed Lizard® array

Stainless Steel Pharmaceutical tank inspection using standard Lizard® probe arrays

After receiving a request from the world's largest NDT inspection company Lizard® was tasked to provide enabling technology and procedures for the inspection of product reactor vessels within a pharmaceutical plant such that non-ferrous inspections could be performed to detect stress corrosion cracking in stainless vessels without any external contamination. This application was extremely successful and enabled significant downtime of the asset.

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Marine and Offshore Structures

Offshore structures such as fixed drilling and production platforms are in many cases built with large tubular steel legs having horizontal and diagonal bracing by further tubular steel members forming complex nodal joints. Following build onshore these structures can experience local overloads during launch and subsequent piling which may give rise to the development of cracks in the welded joints. In addition to this, wave and weather loading on the platforms can develop surface fatigue cracks generally at the toes of the welds on nodal joints. These initial small cracks can grow eventually leading to a through thickness defect and flooding of the nodal member. Since the structure generally has a protective coating to reduce the overall requirement for cathodic protection and to reduce corrosion damage the assessment of the structure requires a method that does not require that this coating be removed or need to be re-instated. Detection of these cracks should be made at a point when they can be removed by remedial grinding since this prevents extremely expensive intervention and repair when these cracks are through thickness. Traditionally, inspection of these structures was performed using Magnetic Particle Inspection (MPI) with fluorescent ink, such inspections required: -

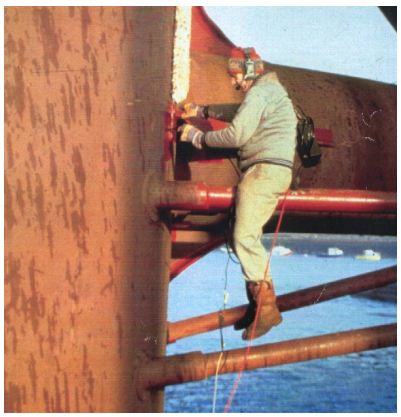
- Inspected surfaces cleaned to bare metal
- Slack tide so that the ink is not washed away
- Darkness so that the fluorescing of the ink can be seen
- Visual access to the inspected site

It is for these reasons that the Lizard® technology was developed and has evolved, supported by Oil majors and certifying authorities. Following exhaustive and successful trialling MPI is being replaced by electromagnetic array technology (such as Lizard® FGI, EMA and Alternating Current Field Measurement) which does not have the restrictions given above and adds the advantage of giving indication of defect depth and making permanent records of the inspection results. Sensor arrays have been developed to meet the various geometries which may be met in complex nodes.

The technology is represented for underwater work by Lizard® NDE's DIVEscan and ROVscan products. These systems feature a portable topside unit needing only a simple umbilical cable to the underwater unit, which may be carried by a diver or mounted upon a Remotely Operated Vehicle. The responsibility for interpreting the results of the inspection is taken by the topside operator, thus reducing the workload on the diver. Users of the system (Shell, Elf, BP and others) have reported substantial savings by its use leading to approval of procedures for frontline inspection from third party approvers such as Lloyds Register, DNV, OCB etc and to DNV approval for class 1A1 mobile structures. The Lizard® technology complies with all current or historic electromagnetic testing regimes including **EN1711**, **EN473** and **ASTM E2261-07.**

Case Study 1

- The Lizard® electromagnetic array technology was chosen for the inspection of the legs of a jack-up rig, these legs consist of tubular columns with tubular cross bracing, they had previously been inspected by the use of MPI. The technology offers significant advantages over MPI, as it does not require the removal then reinstatement of protective paint coats. Once the inspection got underway, the benefits of the decision became particularly obvious. Where the structure had been cleaned to bare metal, coated in MPI ink and then repainted, large pieces of thick flaky rust came off the structure. The effect of the MPI ink had been to prevent the adhesion of subsequent paint coating and the consequent loss of up-to twenty-five percent of the thickness of the metal.



Case Study 2

- During 2008 Lizard® was identified by Det Norske Veritas (DNV) Singapore and Lloyds as the appropriate technology for the assessment of a damaged natural gas platform in the Persian Gulf and to plan for its repair. The new build platform had been struck at night by an unknown vessel causing significant damage to the structural members both above sea level and below. The structure had survived the initial incident however the overall structural integrity of the platform post collision was unknown following the accident. The platform had also been constructed with an expensive lifetime protective coating in place that the owner did not want to remove unnecessarily. The Lizard® technology was employed at the damaged and associated sections of the platform to identify the extent of repairs that were required. This involved the use of rope access technicians for the areas above water and a dive crew with a sub-sea variant of the Lizard® for the affected members sub-sea. This was accomplished in a very short timescale providing detailed information required for the works to be performed for the re-instatement of the platform.

Offshore rope access inspections performed using the Lizard® M8 NDE System

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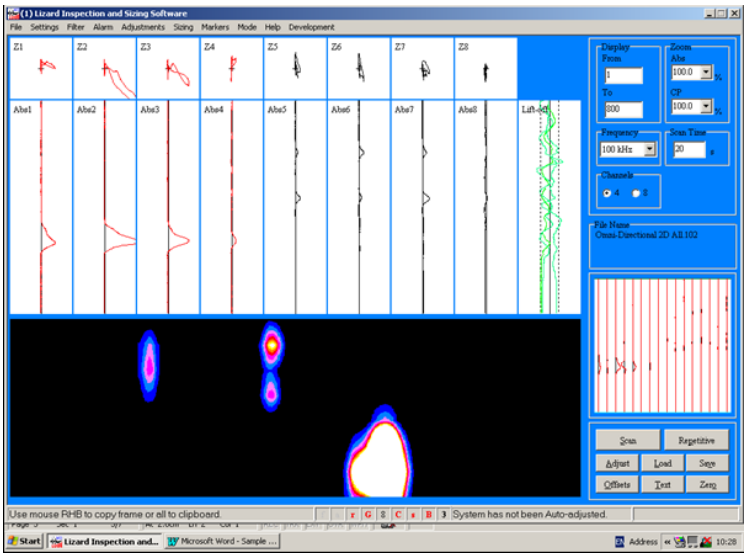
Nuclear



Lizard® FGI display of defect data obtained using the Lizard® Versatile Array system for the inspection of mixed metal alloy welds

Following requests from industry and premier government research laboratories Lizard® developed custom arrays for the inspection of critical components within the Nuclear reactor system. The Lizard® technology evolved into the Versatile Array range of product having the capability to steer the sensitivity of the inspection arrays by excitation controlled by computer and software. This provides an excitation and detection capability ranging from linear through transverse and omni-directional to a scanning direction. In addition multi arrays can be operated separately and independently such that each array can interrogate differing metal compositions during a robotic or manual scanning regime. The Lizard® Versatile Array technology is implemented within two separate arrays which can be scanned together in tandem with other technologies, such as phased array ultrasonics. This gives a full volumetric inspection capability which when coupled with a robotic manipulator allows the full inspection of critical components remotely. In addition differing versatile arrays can be targeted through software to provide for the capability of inspecting differing metal alloys (ferrous and non-ferrous) in a single pass.

In addition to the Versatile Array technology, many of the Lizard® standard probe range are applicable for manual scanning especially the field gradient imaging arrays and software, and can be used to qualify the inspection applications in laboratory testing.

This capability lends itself to the nuclear industry where it is common to have mixed metal welding and non-ferrous cladding with defects that can grow into dissimilar metal to metal regimes. In particular where thermal quench fatigue conditions are present defects may be growing in mixed weld material and propagating to clad areas or growing in one or the other of these regions independently. Since these are surface fatigue events they are difficult to confirm the detection of them with ultrasonics. However in addition to a versatile array sensor package a phased array ultrasonic inspection regime can be accommodated such that both technologies offer the best and most appropriate approach.

Case Study

- Lizard has had a close relationship with a Government research institute who have been utilising the Lizard® M8 and multi-mode software to explore solutions to inspection requirements within the Nuclear industry that were critical and required novel non-destructive testing methods and robotic access to provide a high quality integrity assessment of certain nuclear reactor components for a PWR on site nuclear power generation facility. Full size components were exposed to thermal fatigue and stressing such as to generate laboratory samples having a spectrum of locations and sizes of fatigue defects at sites of cladding of parent plate and at non-ferrous alloy profile ground welds. Laboratory tests using the Lizard® M8 and a range of field gradient and classic probes provided information and assurance of the technology and form of Versatile Array that could be deployed with a robotic scanner. The unique technology of the Versatile Array enabled the construction of arrays contained within an extremely thin section to accommodate the access between the target structure for inspection and the nozzle wall giving Field Gradient image capability of defect depth and length. In order to ensure that cross checking and additional confirmation could be provided the Lizard® technology was combined with phased array ultrasonics in a composite system with Lizard® providing additional control of the robotic scanning software. The Versatile Array and phased array ultrasonics operated in conjunction with data being transmitted through a two wire link to the scan controller and host data capture and analysis hardware sited hundreds of metres away from the inspection site. The program was completed successfully and additional work to further enhance the scanning and presentation of data is planned for the next inspection campaign.

CAD image of the robotic manipulator used for the automated scanning of the Lizard Versatile Array sensor. The Lizard's ability to utilise two dimensional array configurations were essential to the application due to the access limitations on site

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Rail

The Lizard® technology is an ideal fit for the inspection of railway vehicles and infrastructure due to the versatility of the Lizard® FGI system. Arrays can be configured to suit the application required, whether this is the interrogation of complex components in situ through protective coatings with no requirement to clean the application piece or lengths of rail and switchblades. Due to the non-contacting nature of the Lizard® technology rapid inspection can be performed.

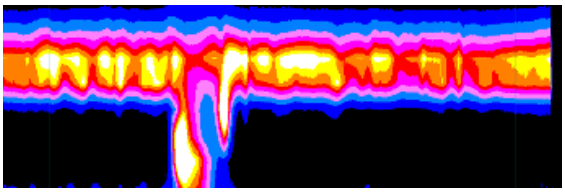
It was identified by the rail industry following a major derailment due to an axle failure that traditional inspection regimes have poor traceability, human variability (error, boredom, skill), limited probability of detection, no depth information (crack or scratch) and relied on extensive cleaning for the inspection to be performed. By using the Lizard® technology these limiting factors are overcome and major economic constraints removed such as risk of affecting the component surface, polluting adjacent equipment and extensive difficulty to re-apply the original metal protection system.

The two dimensional planar arrays employed by the Lizard® technology are able to act as a three dimensional array enabling access to usually unaccessible regions that previously would have required the disassembly of the component. This leads to a significant reduction in downtime of the asset and the ability to schedule inspection maintenance into the daily work schedule.

The technology has been approved, pioneered and accredited into passenger and freight rolling stock, rail switchblades and plain rail initially internationally by Alstom Transport and thereafter by major rail vehicle manufacturers and operators together with infrastructure providers throughout the world. The rail industry has recognised that the Lizard® technology can be adapted to suit existing maintenance and inspection procedures and has been used to return vehicle and rail to operation where these procedures fail and a safety notice requires a rapid intervention, new procedure and return the asset to use or extend the asset life whilst monitoring the true defect size and factors determining defect growth.

Case Study 1

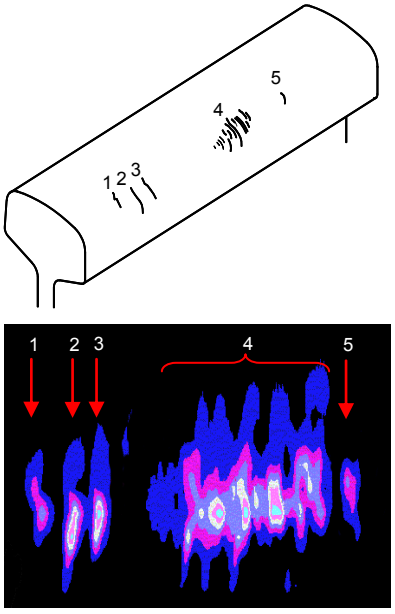
- The Lizard® FGI technology was identified by a major passenger vehicle manufacturer as a possible means of inspection technique for the wheel tread on their new build passenger trains. This manufacturer was experiencing severe damage on the running face of the wheel tread and they were unable to correctly identify the extent or cause of the damage across the fleet. The standard inspection regimes in place did not address this location of damage and visual inspection failed to offer the information that was required. The Lizard® FGI technology was adapted to suit the profile of the wheel tread and configured to identify profile wear, crack location and severity as well as areas of work hardening (upper bainite and martensite) that were later identified to be areas of damage caused by a faulty set up of the ABS braking system. The manufacturer were able to feed the data obtained by the Lizard® technology back into the ride design team to address the issue and significantly reduce wheel wear allowing longer periods between wheel re-profiling and replacement.



Lizard FGI display of narrow running band damage of a wheel tread with microstructure change and micro-cracking, the brighter the palette the greater the severity. The transverse 'smear' across the image is evidence of slip/skid damage

Case Study 2

- Railtrack Plc identify the Lizard® technology as a possible means of detection and quantification of crack like defects in the rail head on the UK rail network, known as 'Rolling Contact Fatigue' or 'Gauge Corner Cracking'. The ultrasonic technology that was employed as the detection device for rail at the time was mainly configured towards identifying internal manufacturing defects (inclusions and tache ovales). Ultrasonic inspection could not identify the extent of damage related to rolling contact fatigue since the ultrasonic method could not measure the depths of the tightly spaced defects, neither could the ultrasound penetrate through the rolling contact fatigue to identify critical defects. The Lizard® FGI technology was adapted to suit the application and 2 versions of technology produced, a trolley mounted unit for the inspection of plain line and a handheld system for the inspection of switchblades (points). During the development switchblades had been identified as the highest risk location due to the high risk of derailment following a failure and a subsequent safety case imposed leading to severe speed restrictions on the UK network. Alstom are tasked with the inspection of the switchblades using the Lizard® and following some 20,000 inspections the safety case is lifted. It was discovered during development that rails typically have a very high proportion of defects leading to the development and release of the Lizard® NEST software, a management system for the automatic analysis and identification of large proportions of defect data.



Typical Lizard® FGI display of 'Rolling Contact Fatigue' on plain rail containing 4 single events (1, 2, 3 and 5) and 1 cluster (identified as 4)

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Industrial, Pharmaceutical and Novel Applications

The Lizard® NDE technology lends itself to many applications in the industrial sector where the benefits of the ability to inspect through protective coatings is required. In many industrial applications corrosion resistant alloys and stainless steels are employed with high temperatures and conditions that provide for environmental and process damage by stress corrosion and corrosion fatigue. Here specialist methods, arrays and software have been developed through blue chip company campaigns which have resulted in the ability to detect and quantify defects that have little or no preferred orientation of growth. In many of these cases the use of liquid penetrants to provide contrast to aid defect detection cannot be employed since the solvent evaporates rapidly at temperature or the colour contrast enhancer is absorbed by the oxidised layer of the non-ferrous material and appears as a colour changed structure, therefore providing little or no contrast between the undamaged surface and the defect to be detected.

Hydro cracking plant where the principle application is the many internal trays and their attachment to the vessel walls with site welds and remedial grinding

Standard Lizard® arrays can be employed on non-ferrous structures and components whilst specialist arrays can enable large area inspection in a single pass. Lizard® offer arrays that operate at high temperatures and can be deployed for large areas either robotically or manually.

Case Study 1

In critical component manufacture Lizard® have provided automated inspection systems for clients to check and separate extruded aluminium alloy bar stock destined for aerospace fasteners and closing blind holes in machined structural components. This was a turn key project to solve a problem in a client manufacturing process in a plant supplying critical components for industry. Here the project started at the stock material that was destined for extrusion and led to the installation of an automated testing facility to determine the quality of the bar stock prior to final extrusion.

Case Study 2

During construction and site erection of a geodetic structure it was necessary to provide a procedure for determining the presence and extent of possible thermal gradient cracking in geodetic tubulars following hot zinc dip. The Lizard® technology was employed due to the ability to inspect through the zinc coating and provide an omni-directional array to allow access to critical locations. The procedures and technique was developed in conjunction with one of the UK's premier civil engineering consultancies and deployed on engineering sections and samples to determine the procedure and form of array to provide the necessary capability. Access to the main span was only possible by using skilled rope access engineers with the electronics and data acquisition package attached to the rope access operator for performing the array scanning with data transferred to the remote system operator, data storage and interpretation which was in this case some 200 metres from the inspection site. This campaign enabled the client to have a high level of confidence at very low cost in the structure during the site build and an archive to act as a baseline against future inspection campaigns.

Lizard® inspection of geodetic structure using rope access operators

Case Study 3

Instructed by one of the world's largest inspection companies Lizard® were able to solve the requirements to inspect the internals of an extremely high quality non-ferrous product reactor vessel in the pharmaceutical industry. The requirement to detect and quantify surface breaking stress corrosion and corrosion fatigue cracking without introducing any contamination which would possibly remain in these sites following inspection with other methods was the prime requirement. Since this was a large pharmaceutical process vessel the inspector was required to enter the vessel with personnel biological protection suiting to prevent contamination by the inspector to the vessel. Standard Lizard® arrays, M8 and software were easily employed and provided a very quick and positive inspection locating small defects which could be eliminated or treated. Using specialist arrays on very small vessels Lizard® were successful in determining the extent and location of near through wall stress corrosion and corrosion fatigue defects.

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Ministry of Defence

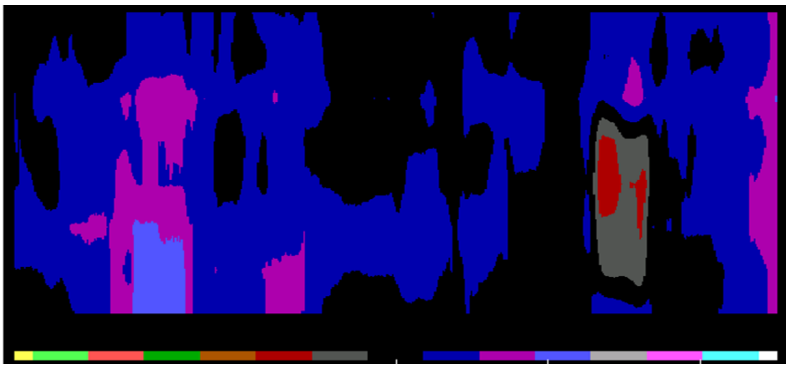
The advantages of the Lizard® technology lend themselves to the life extension of high value assets within the Ministry of Defence where availability of the asset and maintenance intervention are extremely costly and critical when the asset is needed to perform it's role. The use of the Lizard® technology enables the Ministry of Defence to perform inspection tasks without the requirement of dry docking of the vessel, enabling economic benefits from avoiding a docking of an asset completely outweigh the cost for an in situ intervention with an otherwise operational asset. With nuclear powered vessels this cost can be very considerable particularly if the intervention requires structural removal of existing machinery or other components in order to provide access such is the case with propeller shafts and air bottles.

The Lizard technology had been used extensively to extend the operational life of HMS Fearless

As with the oil and gas offshore industry the Ministry of Defence have recognised the advantages of a technology and procedures that can successfully 'see through' protective coatings to at least 8mm thick without the need for any couplant or coating preparation. Typically coatings on submarine tail-shafts consist of protective layers of Denso tape and epoxy composite bandage to at least these thicknesses and in many occasions in a free full compartment. A single array mounted above the coating can therefore inspect the layer of the shaft beneath by simply rotating the shaft. It can even be accomplished along the dock side by intervention of a diver into this space an manually scanning the external protected shaft or component. Lizard® sensors can also be remedially placed in critical locations either in re-fit or during a tour of duty to enable remote acquisition of integrity of specific areas from these electronically scanned foot prints under the arrays.

Case Study

Tasked by Naval Architects of the Ministry of Defence Lizard® technology was identified as a method of detection and quantifying of corrosion and pitting on the internal wall of the massive diesel tanks for HMS Fearless. The tanks were known to have been biologically infected with a micro-organism under anaerobic conditions that excreted sulphuric acid as a by product leading to severe corrosion on the inner walls of the massive diesel storage tanks, the bottom of which formed the ship's hull. The program had to be capable of delivering the correct data without the requirement to dry-dock the ship. In addition certain structural members needed to be cleared in terms of target defects in order to extend the service life of the asset. In order to identify the extent and form of the corrosion a Lizard® array probe, software and procedure was developed to image the corrosion pits from the inside of the diesel tank. Using this data together with finite element analysis of the form of stress intensity generated by the location and shape enabled the operational envelope of the ship to be extended for a further five years. Repairs where necessary were able to be targeted to specific areas of damage and those areas imaged against adjacent regions to ensure structural integrity.



Lizard® FGI scan data displaying areas of material loss due to corrosion pitting on the inside of a diesel tank. The colour scale is used to indicate severity of loss with black being identified as 'good' plate. The grey and red area is a location of increased material thickness, in this instance it indicates where a remedial welding operation has been performed that raises the profile of the plate

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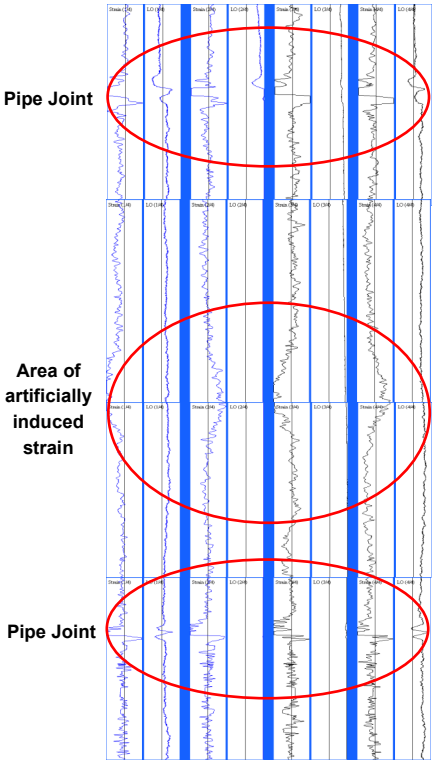
Pipe line

The requirement for the inspection of the integrity of a pipe line is dependant upon the material properties in terms of micro-structure and preferred texture within the manufacturing processes and subsequent heat treatment during manufacture. Ageing pipelines within many countries were constructed and laid within the Victorian era and consisted mainly of cast iron with spun or continuous casting fabrication. These materials are particularly difficult to inspect since they are highly dendritic crystalline structures with a preferred orientation perpendicular to the pipe walls. The walls are thick to support the development of tensile strain fields within the pipe which could cause transverse and mixed mode brittle fracture. In addition these cast materials can contain high levels of inclusions present in their microstructure originating from the melting and casting process and production of slag. These inclusions in the absence of any hot work are generally spheroidal but can be present as laminations. Catastrophic damage can occur when bending or compression of the pipe wall is present due to external overload in the presence of a stress raiser such as underlying bricks or tree roots.

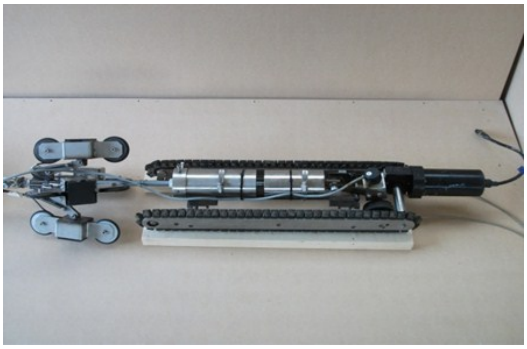


Lizard® Strain Sensor Data following a single pass through a 10 metre length of 10 inch cast iron pipe

Generally stress levels from the internal pressure are not a forcing function since the products carried are at low pressure compared with the design of the hoop and longitudinal strain developed, where failure if this were not the case would be a longitudinal defect burst since the hoop stress is twice the longitudinal. In collaboration with DVS Technology the Lizard® technology has offered a unique solution for the integrity assessment of these pipelines being able to non-contact measure the local strain in the pipe wall which correlates to the detection of internal and external wall defects.

Case Study - Lizard and DVST

DVS Technology are specialists in in-situ lining of pipelines and pipeline asset managers. DVST operates a collaboration agreement with Morrison Utility Services to provide pipeline condition assessment surveys for Utility Clients. As such DVST are ideally placed to respond to the needs of the pipeline industry and search for methods, procedures and technology that could provide for better asset management and life extension. DVST identified Lizard® to initially accurately measure in situ the thickness of applied structural lining in water and gas pipelines following remedial processes to apply protective coatings to aging pipelines. This resulted in a very successful solution and procedure which was trialled and delivered and is currently part of an on-going program supported by the utilities in the UK. Following the success of the lining thickness measurement application the attention was turned to the assessment of the pipe material before and after spraying of the applied structural lining. Lizard developed a proof of principle solution to detect near and far wall corrosion and crack like defects in metallic pipe from a single sensor inside the pipe using the Lizard® Versatile Array technology (originally designed for the assessment of assets in the Nuclear industry). As part of the program Lizard also develop the world's first non-contacting strain sensor to identify areas of strain in the pipe wall. This proof of principle has been developed further into a field demonstration system and successfully deployed in a real world environment. This has resulted in a complete pipeline integrity asset inspection and management system having the ability to assess damage severity from the strain measurement associated with the location and magnitude and form of damage to the pipeline wall. DVST and Lizard are now collaborating to produce a multi-channel intelligent tool, procedures, management database and associated service to the utility industry.



Pipe crawler configured with the Lizard® Strain sensor attachments

The Lizard® FGI pipe inspection system deployed in a 10 inch pipe for the single pass identification of defects on the inside and outside pipe wall

Tel - 0044 2392 449 656 Email - info@lizard.co.uk